Trend of Gas Turbine Technology

Asian-born Gas Turbines for CES

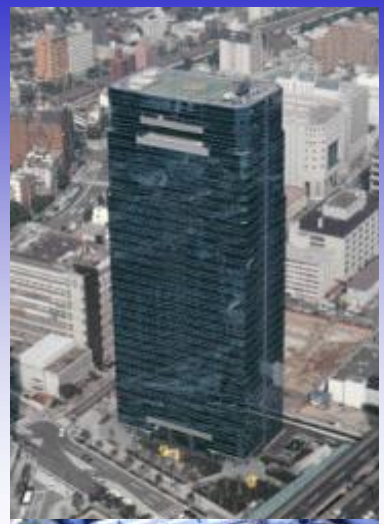
Kawasaki Heavy Industries, Ltd
2008.4.2

Kawasaki Heavy Industries, Ltd.
Organization as of April, 2006

President Tadaharu Ohashi

Aerospace

Headquarter



Technical Institute

Rolling Stock

Gas Turbine & Machinery

Consumer Product

Kawasaki Plant Systems, Ltd

Earth Technica Co.,Ltd.(*)

Split off as of Apr. 1, 2005

Kawasaki Shipbuilding Corp.

Split Off as of Oct. 1, 2002

(*)Note:Joint Company with Kobe Steel Ltd.

Gas Turbine Division Product

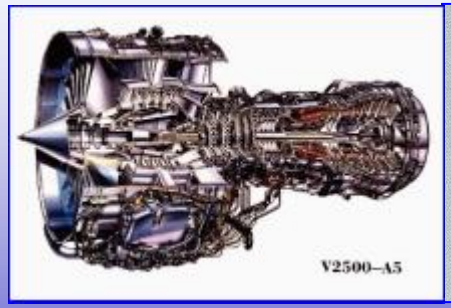
Industrial

L20A Gas Turbine
GPB180 Package

Marine (Naval)

SM1C
Marine Gas Turbine

Aero (Civil)



A320 V2500Engine
(Production Sharing Partnership)

Aero (Defense)

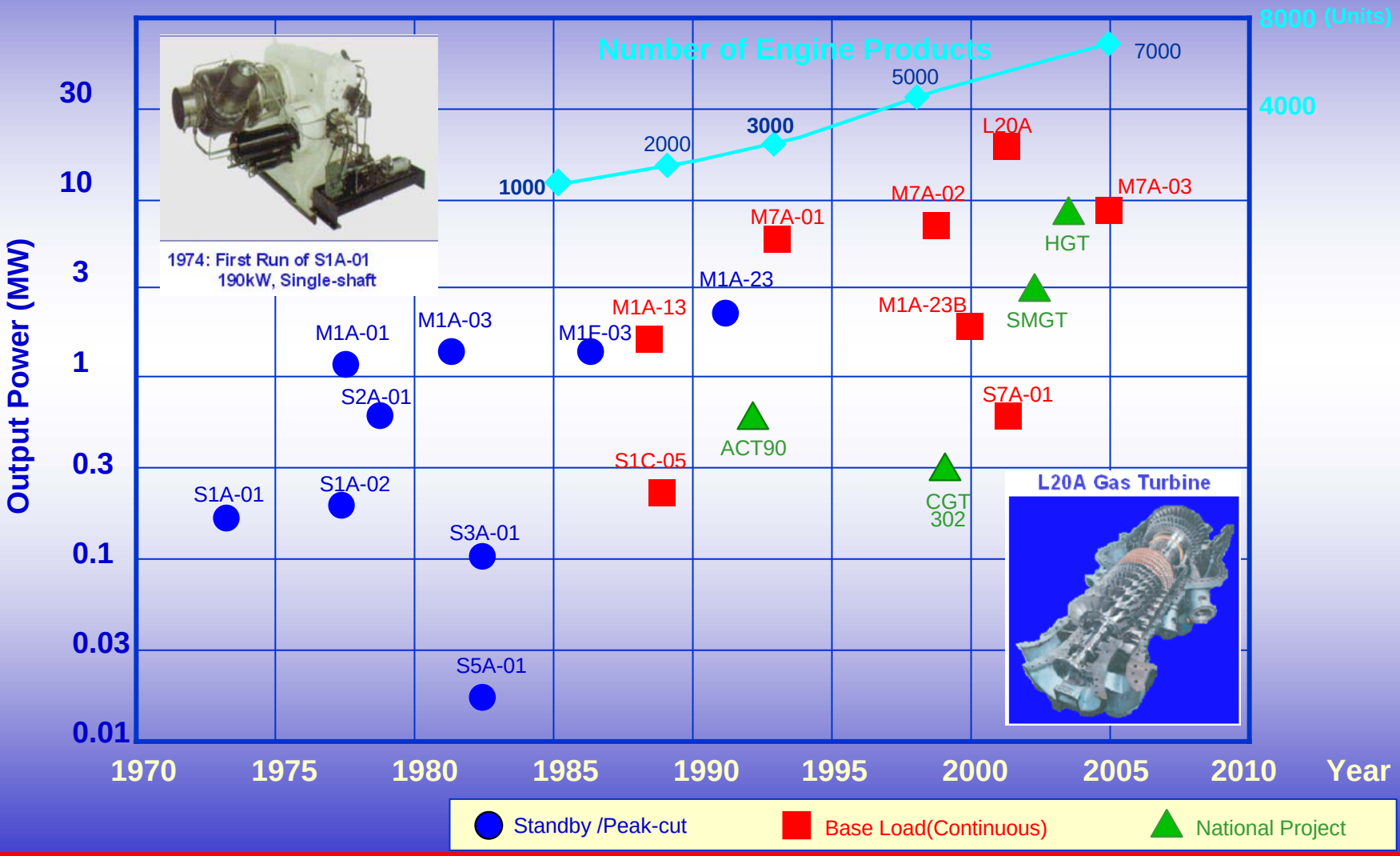
CH-47 T55Engine

History of Kawasaki Industrial Gas Turbine

From Small to Medium with own Technology

1943	● Completed the first gas turbine engine for aircrafts in Japan
1952	● Started overhauling jet engines
1972	**● Started development of industrial gas turbine**
1974	● Completed first S1A-01 type : 200kW gas turbine
1977	● First Kawasaki gas turbine genset : 200kW delivered
1979	● First genset to overseas customer delivered
1984	● First Kawasaki Gas Turbine Co-generation system 2x1.0 MW delivered
1985	● Accumulated delivery of 1,000th set
1988	**● 1.5MW M1A-13 type gas turbine completed**
1993	**● 5.5MW M7A-01 type gas turbine completed**
1995	● 1.5MW M1A-13D Dry Low NOx type gas turbine completed
1998	● Overseas sales and service affiliates were established in the U.S., Germany and Malaysia
1999	● 6.5MW M7A-02 type gas turbine completed
	● 5.5MW M7A-01D Dry Low NOx type gas turbine completed
	● Accumulated order of 5,000th engine
	● Experimental ceramic gas turbine completed and achieved the world record of 42.1% in 300kW class
2000	**● 18MW L20A gas turbine completed**
2001	● Akashi Works NO.4 Power Plant of GPC180D : 17.6 MW commercial start-up
2005	● Akashi Works Energy Center, which comprises 24.7MW Combined Cycle and 7.8MW Flexible Heat and Power Gas Turbine Power Plant, start-up
2006	● 7.7 MW class M7A-03 type gas turbine completed.

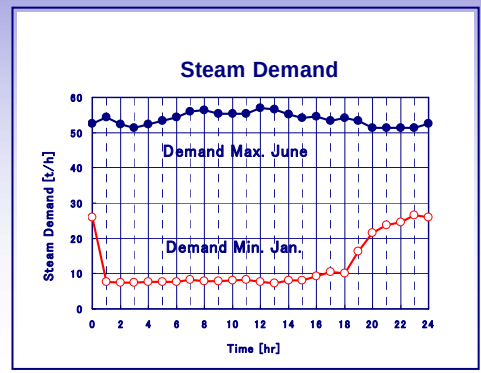
Evolution of Industrial Gas Turbine



Special Features of GTG for CHP

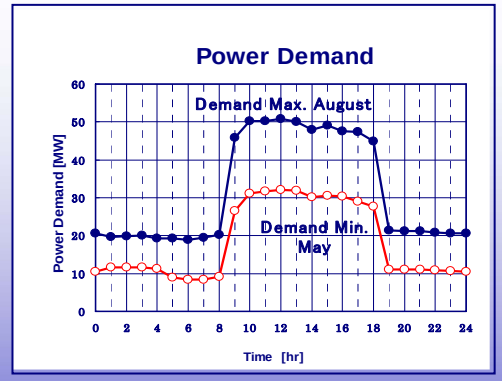
Large size GTG for utility

1. Stable power demands
2. High electrical efficiency
3. Continuous operation
4. High reliability with high price



Small & Medium size GTG for CHP (CES)

1. Fluctuated heat and power demands
2. High CHP efficiency
3. Continuous/DSS/WSS operation
4. High reliability with relatively low price
5. High starting reliability



DSS: Daily Start and Stop, WSS: Weekly Start and Stop

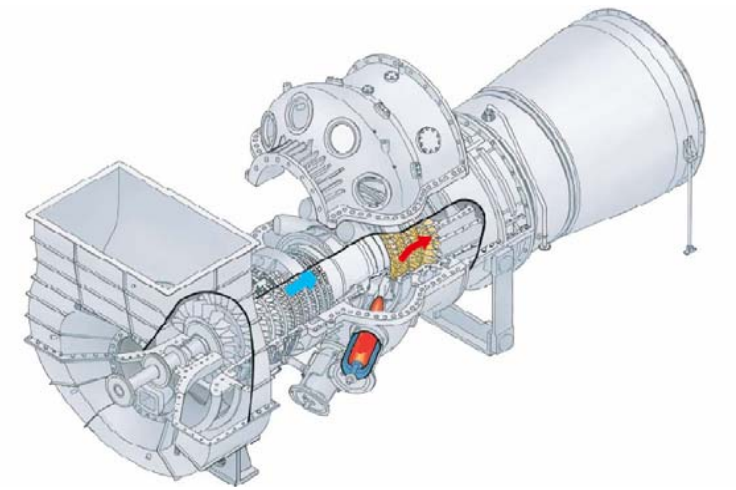
Key factors for CES Business

- Less use of scarce primary energy sources
- Lower investment cost
- Lower O&M cost
- Lower emissions
- Reliable heat and power supply

- Highly efficient GTG for CHP(CES)
- Fuel flexibility
- Low lifecycle cost (LCC) design
- Glocal (Global and local) maintenance service
- Low NOx emission
- Reliable equipment supply

GPB180D
Gas Turbine Generator Set

GPB180D (L20A) Gas Turbine
Lower life cycle cost for power production



Concept of Development:

-Lower Fuel Cost, High Efficiency

High TIT, High Pressure Ratio

-High Exhaust Gas Energy

Reasonably High Exhaust Gas Temperature

-Low Emission

Dry Low Emission system

Design:

-Low Cost Design

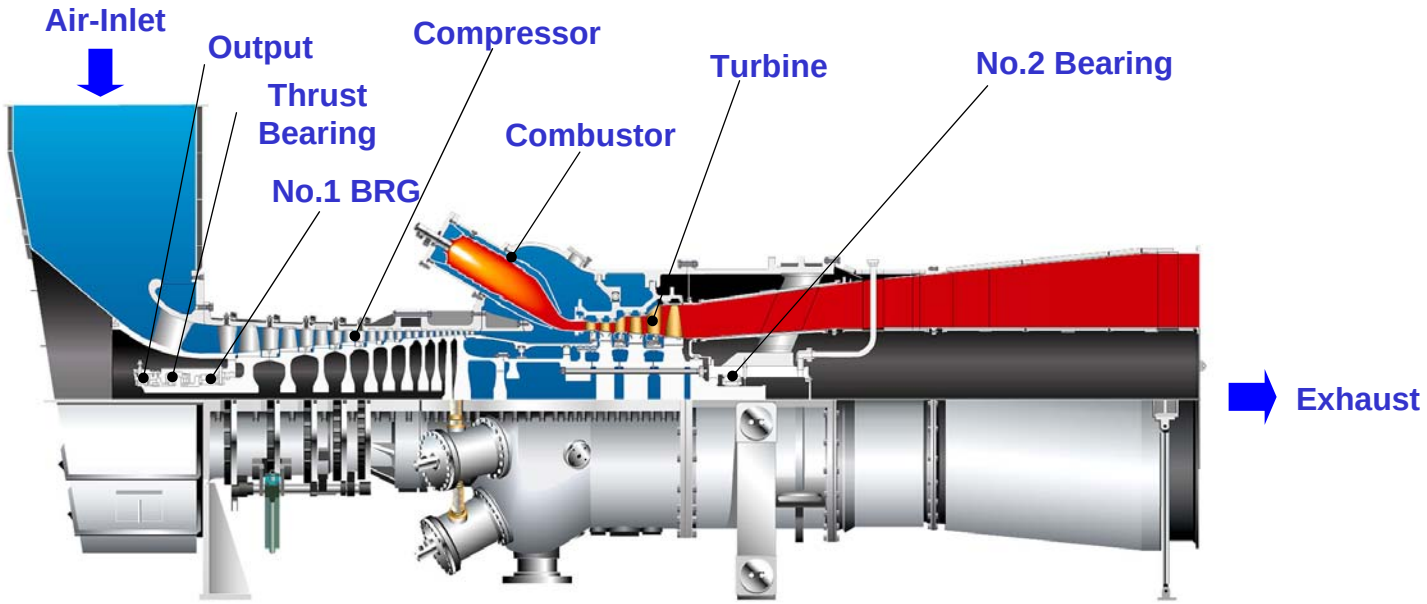
Minimum Compressor & Turbine Stages

Compressor 11 Stages, Turbine 3 Stages

Low Maintenance Cost:

-Robust & Long Life Design

GPB180D (L20A) Gas Turbine
Design Specification

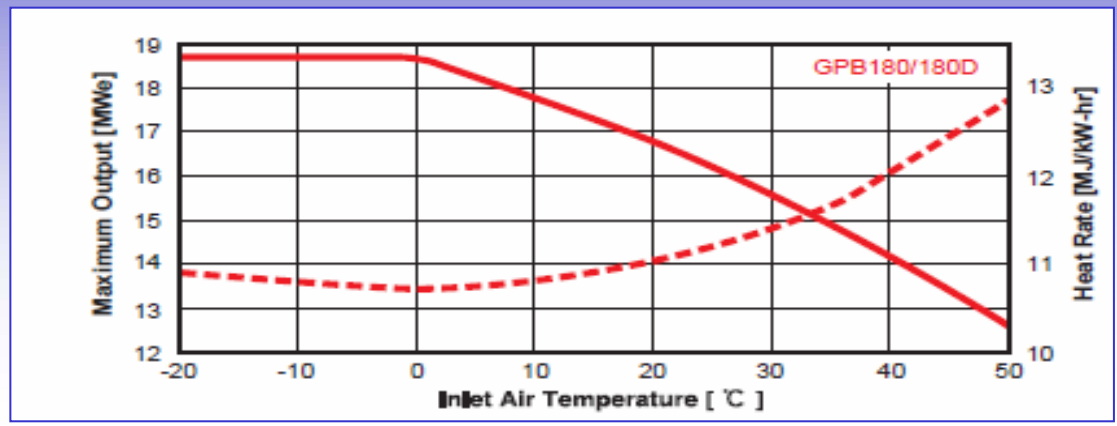


Generator End output	17.84MWe (ISO,100%CH4))
Rotating speed	9420 rpm
Inlet air flow	58 kg/s
Pressure ratio	18.3
Turbine inlet temp.	1250 ℃
Exhaust gas temp.	542 ℃
Emission	NOx < 23 ppm (O_2=15%) CO < 25 ppm (O_2=15%)

Type	Single shaft
Dimension	L6.6m × H2.7m × W2.2m
Weight	14Ton
Compressor	Axial 11 stages
Combustor	8 cans
Turbine	Axial 3 stages

Specifications are subject to change without prior notice.

GPB180D Gas Turbine Generator Set Performance



Partial Load @ Inlet Air Temp.15℃	%	100	75	50
Electric Output	kWe	17,370	13,030	8,690
Heat Rate	kJ/kW-hr	10,940	12,100	14,270
Exhaust Gas Temperature	℃	546	526	469
Exhaust Gas Mass Flow	x10³ kg/hr	213	193	185
HRSG Steam Output (Typical*1)	x10³ kg/hr	40.3	34.6	27.8
Total Thermal Efficiency	%	81.9	80.4	77.0
Inlet Air Temperature	**℃**	**5**	**25**	**35**
Maximum Continuous Electric Output	kWe	18,260	16,210	14,860
Heat Rate	kJ/kW-hr	10,790	11,230	11,700
Exhaust Gas Temperature	℃	541	555	566
Exhaust Gas Mass Flow	x10³ kg/hr	219	206	198
HRSG Steam Output (Typical*1)	x10³ kg/hr	40.6	40.1	40.1
Total Thermal Efficiency	%	80.9	82.9	84.0

Kawasaki Heavy Industries, Ltd
Facilities for GPB180D

Kawasaki Heavy Industries
Akashi works

Engine Assemble
Complete Engine Power Section at Akashi

Engine Test Cell
Complete Engine Power Section at Akashi

Kawasaki Heavy Industries
Kobe works

High-speed Balancer
Complete rotor Assembly at Kobe

Packaging
Gas Turbine Enclosure at Kobe

Japan KHI Akashi

Japan Chiba-Minato

Iran KPIC

Japan Osaka Gas/ Daihatsu

Japan Mitsubishi/ Kawajiri

Japan Mitsubishi/ Shiohama

Malaysia PML

Korea GwangMyeong

References

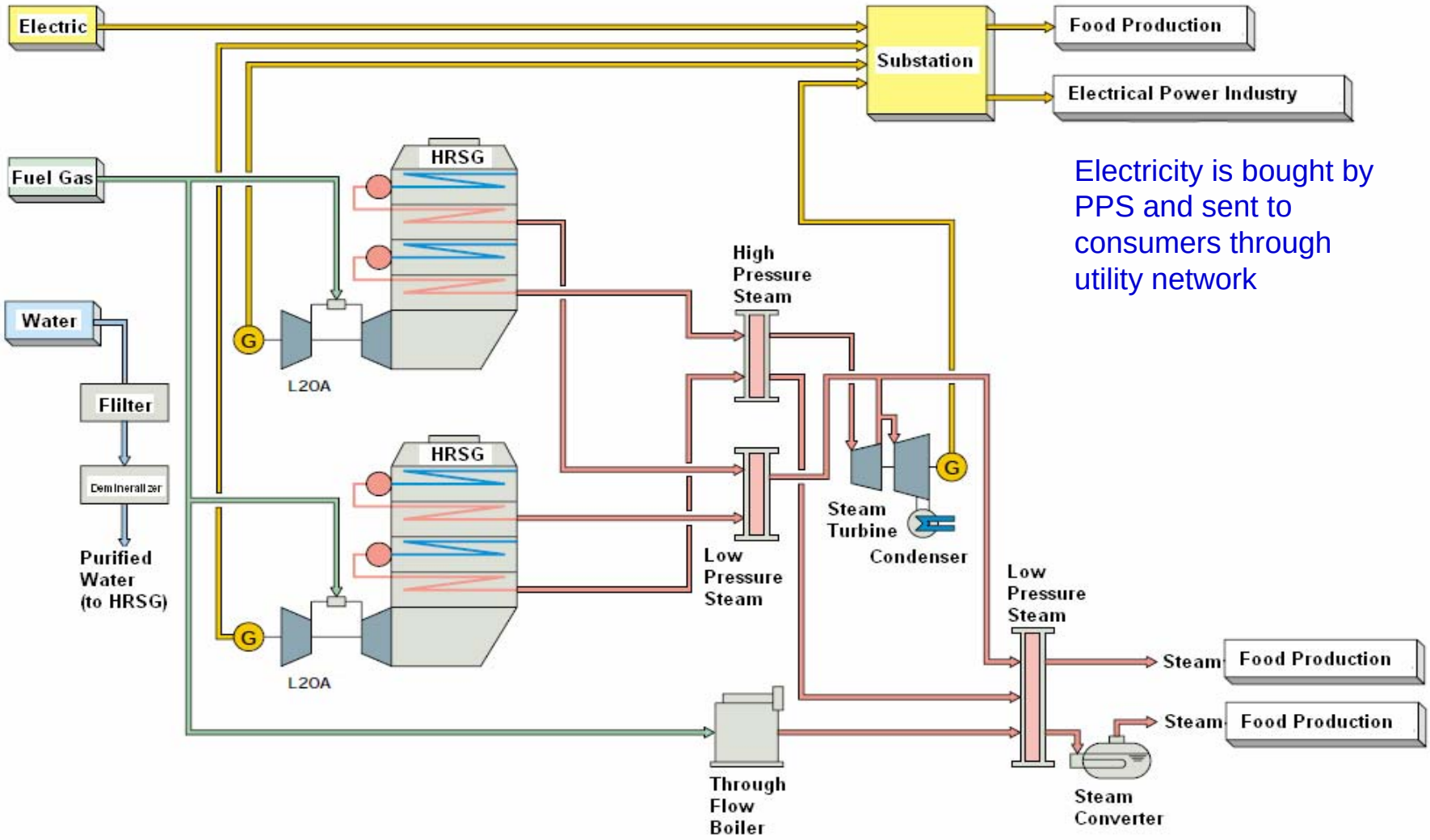
Chiba-Minato Power Station

Owner : Summit Mihama Power Corp.

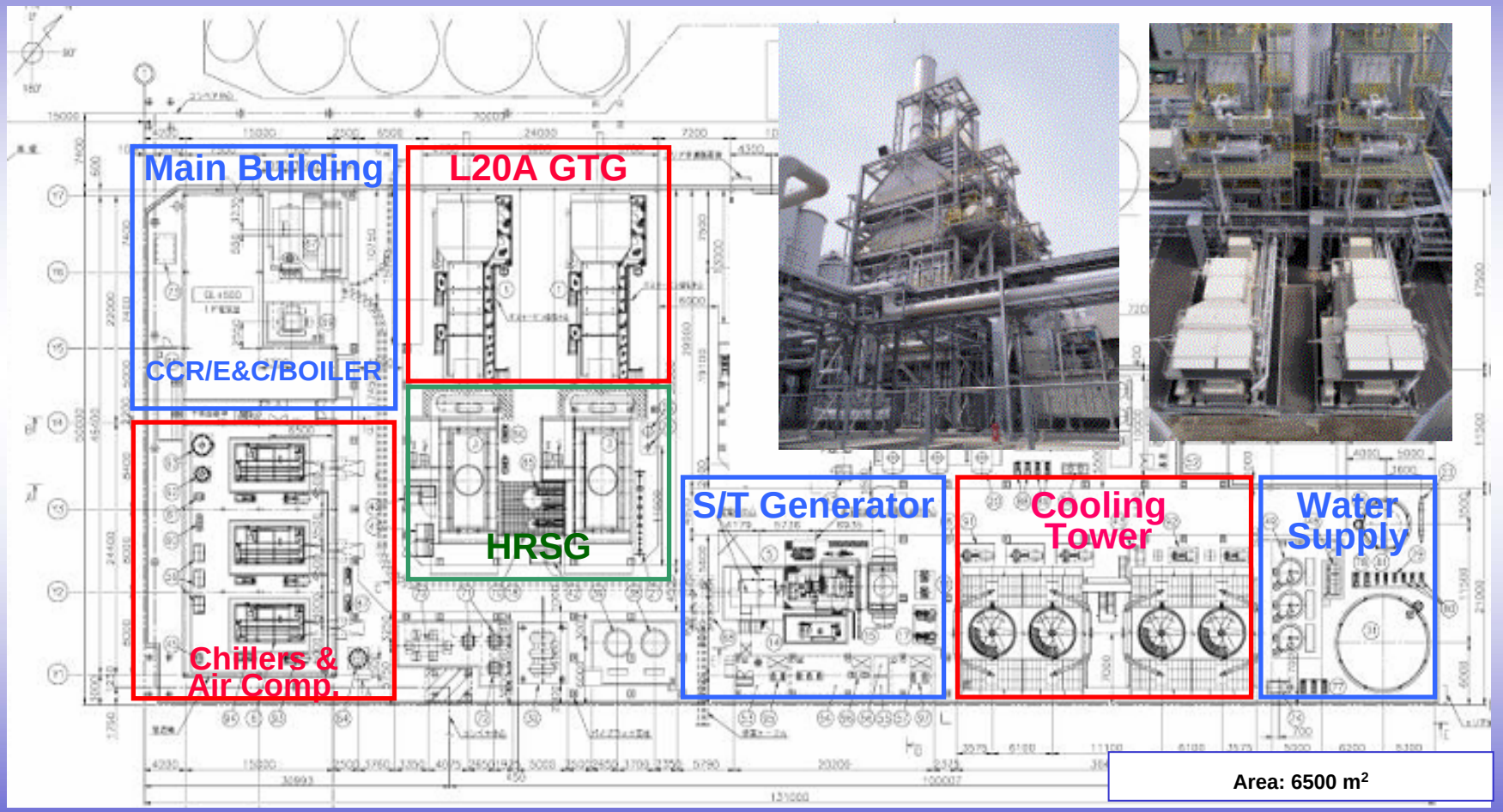
Specifications

- Combined cycle power generation system
- GTG Type GPB180D
- Electrical Output 49MW (GTGx2, STx1)
- Steam 65 t/h (0.83MPaG)
- Fuel City Gas
- NOx 5 ppm (02=16 %)

Chiba-Minato Power Station
System Flow



Chiba-Minato Power Station
General Arrangement



GwangMyeong CES

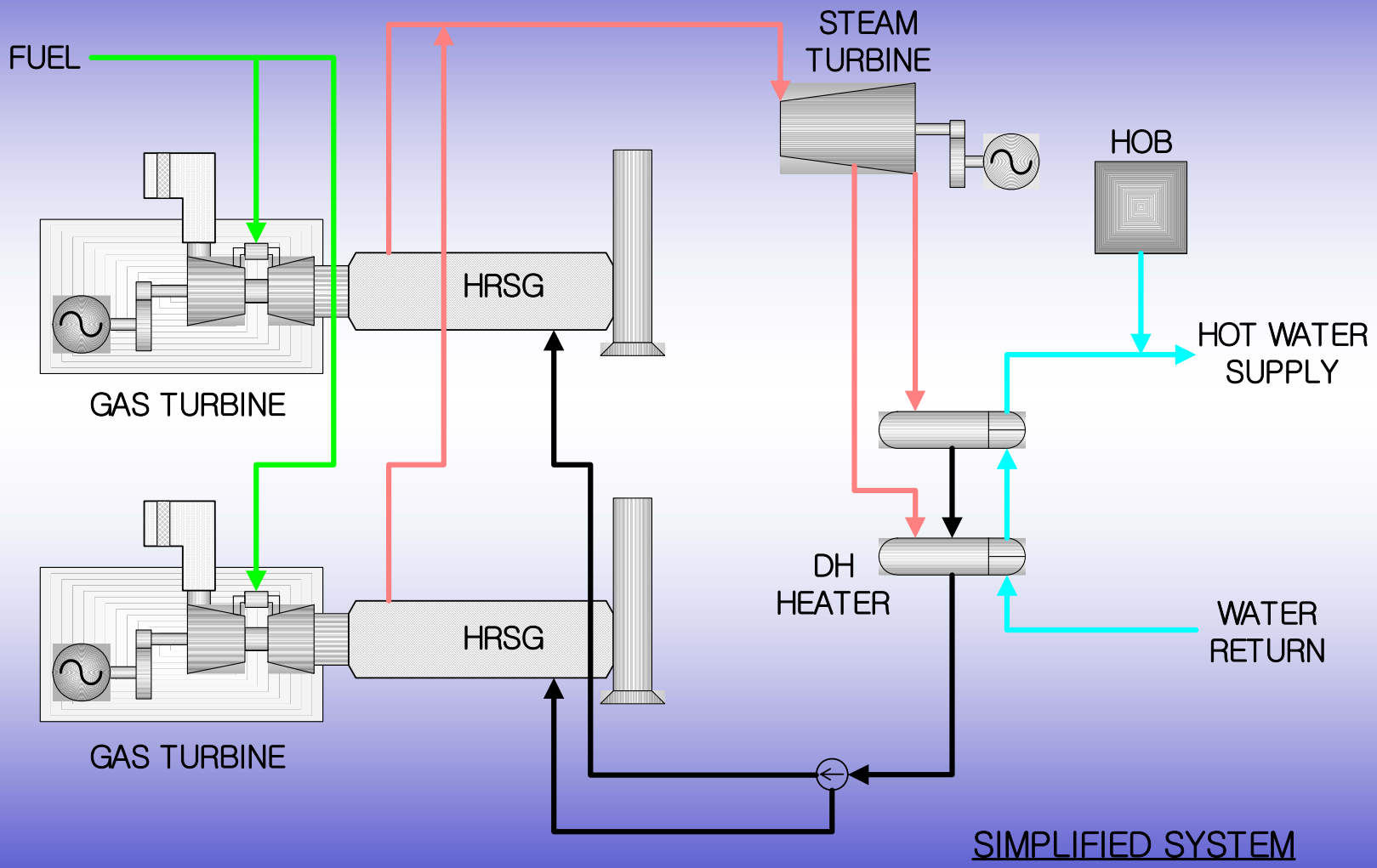
Owner : Samchully

GwangMyeong City

Specifications

- GTG Type GPB180D x 2 (KHI supply)
- STG x 1
- Electrical Output 46MW @15 degC
- Hot water 120 t/h @15 degC
- Fuel City Gas

GwangMyeong CES System Flow Diagram



Maintenance

Inspection Schedule

Engine Inspection Plan (Continuous operation, 0 – 140000 E.O.H. hr year)

Inspection Level		Inspection Interval (E.O.H x10000 hour)				
Inspection D	Initial Bore scope (IBI)	500hr.	-	-	-	-
Inspection C	Bore scope inspection (BSI	-	4	7	10	13
Inspection B	Hot section inspection (HSI)	1,2	5	8	11	14
Inspection A	Overhaul (O/H)	3	6	9	12	-

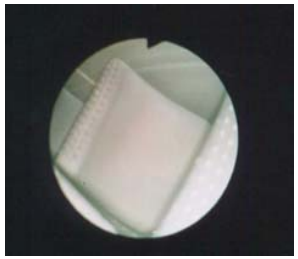
E.O.H x10000 hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14
D:Initial	D													
C : BSI					C			C			C			C
B: HSI		B		B			B		B			B		B
A: O/H						A				A			A	
year**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

** Year : Continuous operation reference E.O.H. 8750 hours per Year

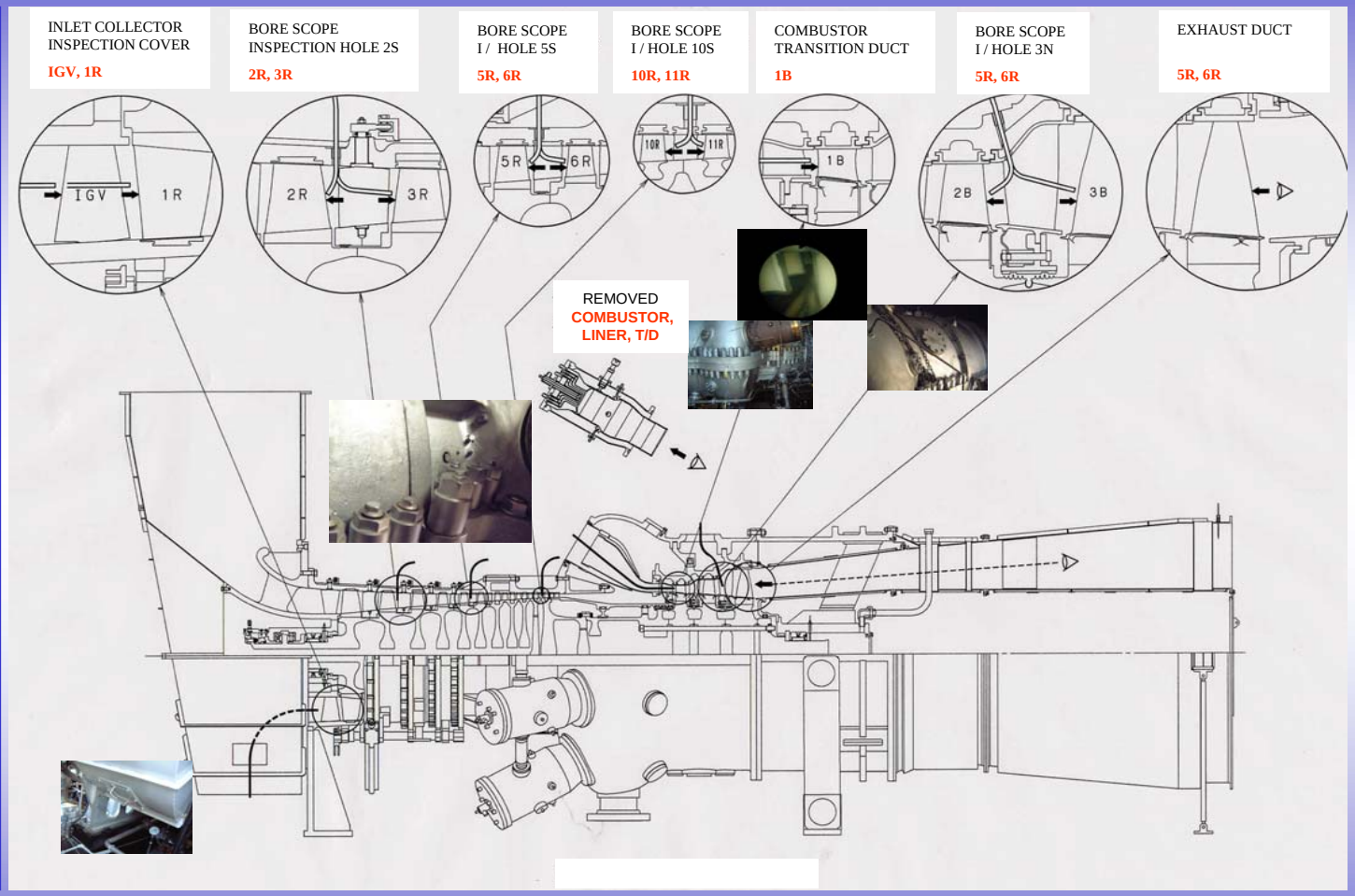
Bore scope Inspection (BSI)

Bore scope Inspection

Bore scope



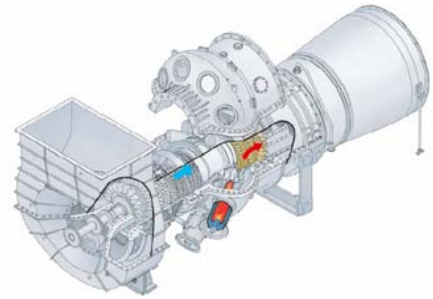
Screen



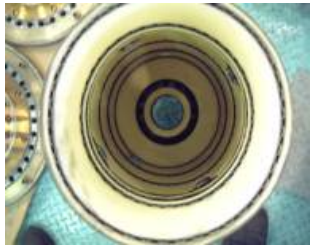
"Bore scope" is an instrument to inspect internal areas of the gas turbine. It is a combination of flexible optical fibers and an illuminating lamp to allow direct look around the scope head. The bore scope inspection is done at site. This maintenance work can be executed without disassembling casings. The flow path inside the gas turbine can be inspected visually by the bore scope through inspection holes and disassembled combustor casing openings.

Hot Section Inspection (HSI)

Remove Main Housing




Combustor Inspection

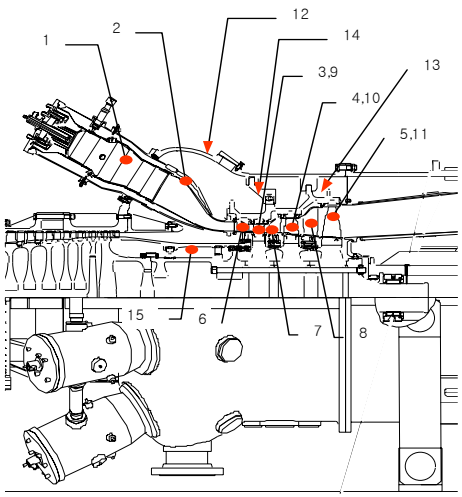



Turbine Inspection


In order to maintain hot section parts at site, the gas turbine is designed to be able to disassemble hot section casings. The hot section inspection makes it possible to inspect all hot section parts and replace almost all of them at site. But a certain maintenance space at site is necessary for this maintenance work. If there is any likely defective part, which needs detailed examination, restore the turbine section by using a spare one of the defective part, and examine and repair the removed defective part separately.

Hot Section Inspection (HSI)

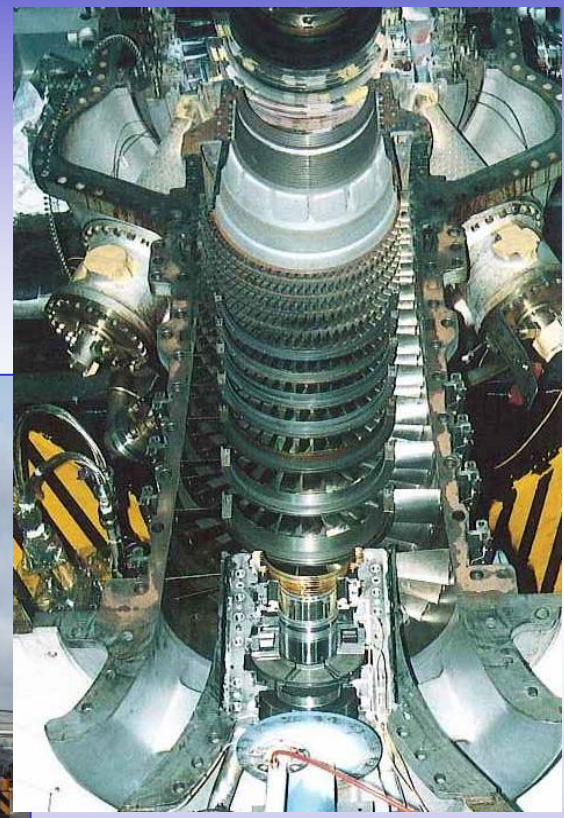
Turbine Inspection



Inspection Parts & Location

1	Combustor Liner
2	Transition Duct
3 –11	Turbine
12	Main HSG
13	Nozzle Support
14	Seal Wall
15	Inner/Outer Diffuser

Overhaul (O/H)



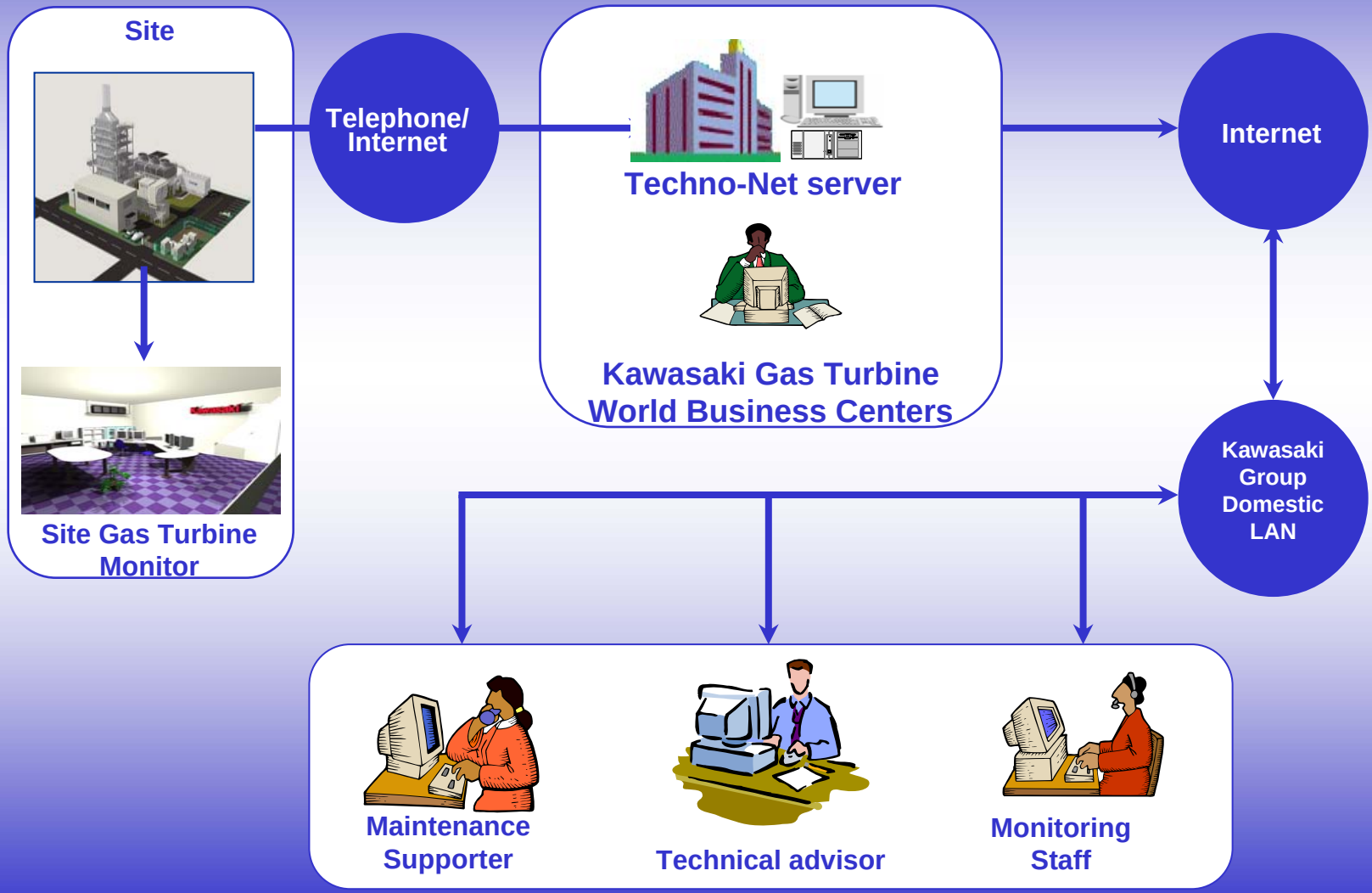
"Overhaul" is executed at Kawasaki factory in Japan. This overhaul inspection is done to check the condition by close examination of all gas turbine parts by disassembling them completely including the compressor. Life-controlled parts and repairable parts are replaced. After examining and replacing work, the gas turbine parts are cleaned and reassembled. High speed balancing of the rotor assembly and mechanical running test of the complete gas turbine are done to confirm the soundness.

Merits of O/H with Engine Exchange

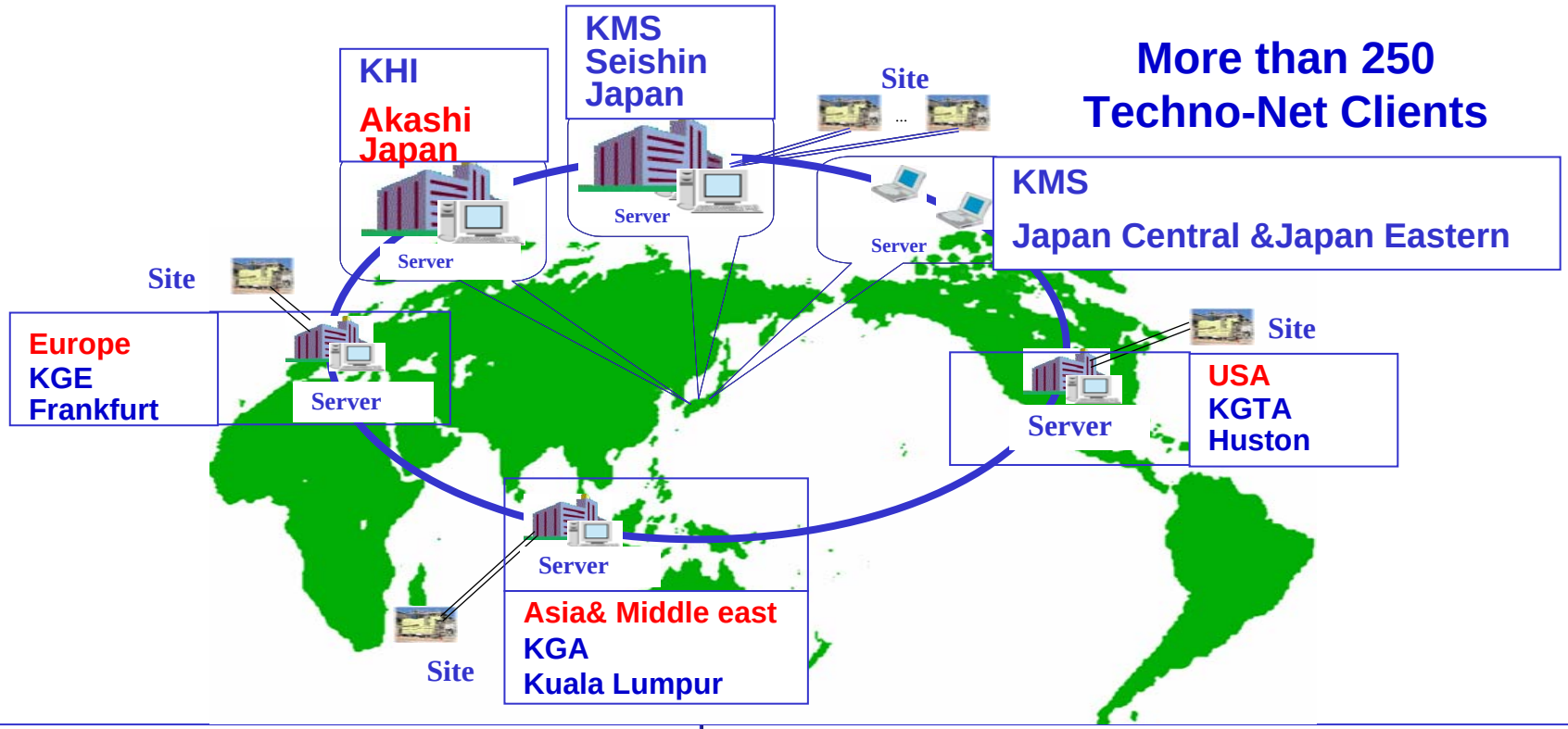
1. Minimized down time
2. Overhaul at GT manufacturing facility
3. Works under Certified Quality Management System
4. Works with qualified engineers and technicians
5. Best O/H facilities with good environment
6. Complete tests including high speed balancing

Remote Monitoring

Techno-Net System
Professional staffs monitor & support customers



Gas Turbine Monitoring
Kawasaki Techno-Net System



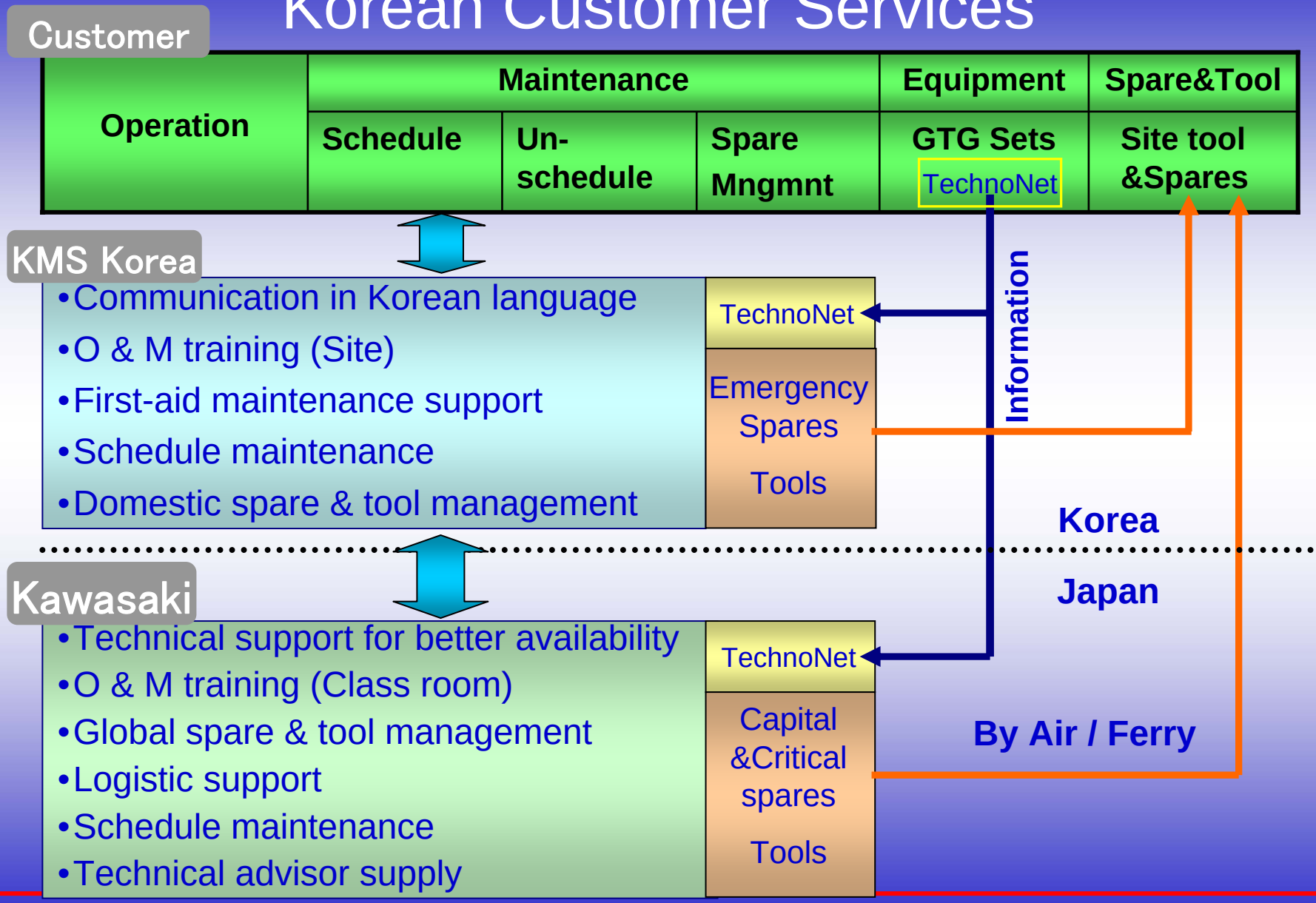
Global remote monitoring

- Remote monitoring through telephone net
- Internet monitoring

Reduction of serious failures

- Enforced monitoring
- Diagnosis

Korean Customer Services



Topics

- Rising GTG Package price
- GT development trend
  - Fuel flexibility
  - Low emission
- Investment cost

Thank you

고맙습니다

Get
Reliable
Eco-friendly
Energy
Now

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